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Effect of Application Several Types of Ameliorants on Nutrient Uptake and Growth of Sweet Corn in Sandy Soil

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Abstract:- The most significant barriers to boosting soil fertility and sweet corn plant growth are porous sandy soil and relatively low water retention capacity. This study aims to see how different types of ameliorants affect the absorption of NP nutrients and the growth of sweet corn (*Zea mays* L. var. *saccharata*) in sandy soil. From May to July 2023, the research was conducted at Moncok Karya, Pejeruk Karya Village, Ampenan District, Mataram City, Indonesia. The trial was set up using a randomized block design with five ameliorant treatments: PO (control), PA (rice husk charcoal rice), PK (compost), PS (cow manure), and PC (a mixture of rice husk charcoal, compost, and cow manure). The results showed that a 20 t ha^{-1} dose of ameliorant rice husk charcoal, compost, and cow dung resulted in N and P nutrient absorption, height, and number of leaves of maize plants at 14, 28, and 42 days after planting (DAP), the highest stover weight per plant, and mycorrhizal growth.

***Keywords**: -Ameliorant, Nitrogen, Sandy Soil, Phosphate.*

I. INTRODUCTION

Sandy land management faces several challenges, including inconsistent rainfall distribution and poor soil fertility, which can lead to yield reduction and crop failure [1]. These sandy soils feature coarse structure, no identifiable horizon, and a 60% or higher sand percentage at depths ranging from 25 to 100 cm [2]. Furthermore, sandy soil has a low organic matter content, a low adsorbability, a low cation exchange capacity (CEC), a high permeability, and an increased vulnerability to erosion [3]. These soils are typically found in volcanic ash parent material and coastal dunes. Soils with a high sand concentration will undoubtedly require more work to use. As a result, efforts must be made to mitigate these issues. Adding ameliorant elements to the soil is one of the measures done.

Composting is one method of adding ameliorants. Compost is an organic ameliorant material that contributes significantly to soil's physical, chemical, and biological qualities. Physical soil serves as an adhesive agent between soil particles, allowing them to union to form soil aggregates, improve soil structure, increase soil porosity, increase the soil's ability to hold water (water holding capacity) and slow the pace of soil erosion [4]. Adding ameliorant elements is expected to shift the soil structure from single-grained to lumpy, increasing the degree of structure and aggregate size or shifting the structural class from fine to medium or coarse [5]. Furthermore, the use of organic materials such as compost can make a significant contribution to soil CEC. Colloids often supply 20-70% of soil CEC, indicating a link between organic matter and soil CEC. [6]. The negative charge of humus yields CEC organic materials. The carboxyl and phenolic groups are the principal sources of negative charge in humus [7]. According to the study, adding 10 tons of straw ha^{-1} to Ultisol can enhance soil CEC by 15.18%, from 17.44 to 20.08 cmol(+) kg^{-1}.[8]. Regarding sandy soil, which has a low ability to store water, this study also included adding organic matter to cow manure. Rice husk charcoal contains activated charcoal, which frees the carbon atom configuration from bonding with other elements and cleans the cavities or pores of different compounds or impurities, allowing the surface and active center to become wider or increase the adsorption capacity of liquids and gases. Given the ability of this rice husk charcoal, sandy land is expected to retain water due to its high adsorption capacity. Furthermore, because charcoal is hygroscopic, it can prevent leaching on sandy land.

Furthermore, the positive interaction between roots and soil bacteria is critical in boosting the fertility of sandy soil. Mycorrhiza microorganisms are beneficial to soil microbes. Mycorrhiza can enhance plant nutrition supply and symbiotically absorb nutrients from plant roots [9]. Rhizobium and mycorrhiza inoculation can boost maize growth and yield. Mycorrhizal inoculation can increase plant root nutrient absorption by 2 to 3 times [10], [11]. In the corn-sorghum cropping pattern on sandy ground in North Lombok, seed coating with indigenous mycorrhizae can boost growth, crop output, plant N and P uptake, and nutrient availability [12]. Applying a fertilization package containing a mixture of inorganic fertilizers, mycorrhizal biofertilizers, and organic materials can increase maize output on dry terrain [13]. Based on this, this study was carried out to assess the effect of several types of ameliorants on enhancing NP nutrient absorption and sweet corn plant development (*Zea mays* L. var. *saccharata*).

II. MATERIALS AND METHODS

A. Research materials and tools

The seed of the sweet corn variety Bonanza F1, Urea fertilizer, Phonska fertilizer, cow manure, mycorrhizal biofertilizer, OrgaNeem pesticide, soybean variety, raffia

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rope, plastic bag, tissue, label paper, soil sample, root sample, methylene blue, 10% KOH, sucrose, distilled water, filter paper, and stationery was used in this experiment. Ovens, scales, binocular microscopes, magnetic stirrers, beakers, tweezers, multilayer filters, centrifuges, funnels, Petri dishes, shovels, hoes, sickles, and hand counters were all employed in this experiment.

B. Research place and design

From May to July 2023, the research was conducted in Moncok Karya, Pejeruk Karya Village, Ampenan District, Mataram City. The trial was set up using a randomized block design with five ameliorant treatments: PO (control), PA (rice husk charcoal rice), PK (compost), PS (cow manure), and PC (a mixture of rice husk charcoal, compost, and cow manure) [14].

C. Conduct of Experiments

The field was initially cleaned of weeds, and then plots were created as treatment sites for the dose of ameliorant, with each experimental plot being 3 m by 2 m in size. The soil was worked with a hoe, irrigation canals were built between plots 50 cm apart, and the beds were 25 cm tall.

Mycorrhizal isolates were propagated in culture pots using corn host plants and a mix of soil and sterile cow dung (50%: 50%) in amounts up to 5 kg. A mixture of soil, roots, spores, and mycorrhizal hyphae was used for mycorrhizal inoculation. The funnel method is used for inoculation, which consists of triangular folded filter paper, 40 g of isolate MAA, and the host plant placed on the filter paper. The soil is then applied to the filter paper, allowing the plants to grow [15], [16].

The application of bioameliorant and mycorrhiza was made at the time of planting. A layer of mixed ameliorant plus mycorrhiza in the form of flour is laid down evenly at a depth of 10 cm to generate a layer with a dose of 20 tons per ha. The ameliorant plus mycorrhiza is a powdered mixture of ameliorant, chopped roots, fungal spores, fungal hyphae, and culture pot media.

Corn seeds are sown in the soil by dipping them. With a corn spacing of 60 x 40 cm, each hole was filled with two corn seeds. Stitching is accomplished by sowing corn seeds at the age of 7 DAP to replace dead or unusually developing plants. Thinning is done after the plants have grown after 14 days by leaving one plant.

Fertilization is accomplished by applying half the required doses of urea fertilizer (175 kg ha^{-1}) and phonska fertilizer (125 kg ha^{-1}) [17]. Essential fertilizer inorganic fertilizer is administered in 1/2 dose at 7 dap and the remaining 1/2 dose at 14 dap. Sweet corn spacing is 40 x 20 cm, with two seeds per planting hole.

Weeding every weed that grows by pulling it out is part of plant upkeep. Plant water is done based on rainfall in the field and with a water sprinkler.

D. Variable observation

The following variables were observed in this study: (1) soil nutrient concentration and plant nutrient uptake (N and P) variables at 42 days after planting, (2) growth variables including plant height and number of leaves at 14, 28, 42, and 56 days after planting, and weight of wet and dry stover roots and shoots at 42 dap, and (3) mycorrhizal population variables including number of spores and percentage of root infection at 42 dap.

III. RESULTS AND DISCUSSION

A. Nutrient concentration and nutrient uptake

The results of the diversity analysis revealed that administering ameliorants in combination with rice husk charcoal, compost, cow manure, and mycorrhizal biofertilizers had a significant effect on soil nutrient concentrations and nutrient uptake by plants when compared to administering ameliorants alone (Table 1). When compared to the control at 42 DAP, the HSD test results at the 5% level showed that the administration of an ameliorant mixture of rice husk charcoal with compost, cow manure, and mycorrhizal biofertilizers could significantly increase the concentration of total N and available P in the soil and the uptake of plant N and P nutrients. The administration of combined ameliorants resulted in the largest and most significant rise.

Table 1. The ameliorant treatment's mean nutritional concentrations and N and P uptake at 42 DAP

Ameliorant Treatment	Soil nutrient concentration		Plant nutrient uptake	
	N total (g.kg^{-1})	P available (mg.kg^{-1})	N uptake (g kg^{-1})	P uptake (g kg^{-1})
PO: Control (without ameliorant)	0.913^{c}	12.756^{d}	25.466^{e}	2.623^{e}
PA: Rice Husk Charcoal	1.150^{b}	18.133^{c}	30.773^{cd}	2.923^{d}
PK: Compos	1.150^{b}	18.283^{c}	32.952^{bc}	3.641^{c}
PS: Cow Manure	1.166^{b}	36.961^{b}	34.406^{b}	$3,881^{b}$
PC: Mixed ameliorant	1.756^{a}	62.966^{a}	44.966^{a}	4.102^{a}
HSD 5%	0.090	4.774	2.419	0.077

Giving up to 20 tons ha^{-1} of mixed ameliorants containing cow dung, compost, and rice husk charcoal can considerably raise the average total N and available P concentration of soil compared to the total N and available P content in the control treatment. This demonstrates that the total N and accessible P content of the soil rose with the addition of organic ameliorants and mycorrhizae. The lowest available P content was obtained in the treatment without ameliorant (control), which was 12.75 mg kg^{-1}, while the highest value was obtained in the combination of mixed

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ameliorant treatment, namely the application of manure + compost + rice husk charcoal + mycorrhiza, which was equal to 62.96 mg kg^{-1} (Table 1). This demonstrates that mixed ameliorant plus mycorrhizal types contribute more soil P since soil research has shown that the mixture of the four elements has a greater P content [18].

When mycorrhizae were added to organic ameliorants, the available P in the soil tended to increase for each treatment given organic ameliorants. This demonstrates that mycorrhiza can convert soil P from a difficult-to-dissolve form to a soluble one, increasing accessible P. Because they create organic acids and phosphatase enzymes, mycorrhizae are hypothesized to be able to take P from mineral sources that are difficult to dissolve. This molecule can break down insoluble P bonds like Al-P and Fe-P, increasing P availability. The findings of this experiment are consistent with the results of another study that found that treating organic ameliorants and mycorrhizae could increase soil phosphate status in Andisol soils [19]. The application of 20 tons ha^{-1} Amelioran, a mixture of 80% chicken manure and 20% dolomite, resulted in the maximum sweet corn dry weight and NPK nutrient absorption [20].

B. Height and number of leaves

The results of the diversity analysis revealed that when the plants were 14-42 DAP, the administration of ameliorant, a mixture of rice husk charcoal with compost, cow manure, and mycorrhizal biofertilizers, made a significant difference in plant height compared to no ameliorant application (control). When the plants were 14-42 DAP, the treatment of an ameliorant mixture of rice husk charcoal with compost, cow dung, and mycorrhizal biofertilizers resulted in a significant difference in the 5% HSD test. The plants were at 42 DAP, plant height, and the number of leaves on the sweet corn plant in the combination ameliorant treatment yielded the maximum yields and was substantially different from the control (Table 2).

Sweet corn plants not treated with ameliorants grew less than those given a combination of ameliorants that included mycorrhizae. Table 2 shows that the mixed ameliorant treatment (cow manure + compost + rice husk charcoal + mycorrhiza) produced the highest plant height and number of leaves. This demonstrates that mycorrhizae-containing mixed ameliorants can promote faster plant development. The combination ameliorant with mycorrhiza treatment improved plant height throughout time, and the number of leaves grew until the age measurement was 42 DAP.

Table 2:- At 14, 28, and 42 DAP, the average plant height and number of leaves in the ameliorant treatment

Ameliorant Treatment	**Plant height (cm)**			**Number of leaves (strands)**		
	14	**28**	**42**	**14**	**28**	**42**
PO: Control (without ameliorant)	15.00^{c}	57.66^{b}	63.00^{d}	5.00^{b}	7.33^{c}	73.33^{e}
PA: Rice Husk Charcoal	23.76^{ab}	92.66^{a}	110.66^{c}	7.33^{ab}	8.66^{bc}	10.33^{d}
PK: Compos	27.50^{ab}	99.66^{a}	112.33^{c}	8.66^{a}	10.33^{a}	11.33^{c}
PS: Cow Manure	30.16^{ab}	98.30^{a}	133.66^{b}	8.00^{ab}	10.00^{ab}	12.33^{b}
PC: Mixed ameliorant	32.56^{a}	100.66^{a}	177.00^{a}	8.66^{a}	10.66^{a}	13.33^{a}
HSD 5%	6.65	25.11	10.04	2.24	1.08	0.32

This demonstrates that administering a mixture of organic ameliorants considerably influences sweet corn plant growth. The organic matter derived from cow manure, compost, and rice husk charcoal, which contained nutrients and organic matter that could improve the physical, chemical, and biological properties of the soil, was primarily responsible for the increase in plant height and number of leaves caused by the application of mixed ameliorants [21]. Adding organic matter is critical for improving the soil's physical, chemical, and biological qualities, allowing plants to grow appropriately [22]. Furthermore, 25% mycorrhiza applied to the ameliorant combination can improve the height and quantity of plant leaves [23]. This is because mycorrhizal plants develop faster than non-mycorrhizal plants. The fundamental reason is that mycorrhizae can significantly boost nutrient absorption, both macronutrients and micronutrients. Aside from that, mycorrhizal roots can take nutrients bound and unavailable to plants [24].

C. Wet and dry biomass weights

The results of the diversity analysis revealed that administering an ameliorant mixture of rice husk charcoal with compost, cow manure, and mycorrhizal biofertilizers had a significant effect on increasing the weight of wet and dry biomass of roots and plant shoots compared to no ameliorant application (Table 3). The HSD test at the 5% level revealed that administration of an ameliorant mixture of rice husk charcoal with compost, cow manure, and mycorrhizal biofertilizer increased the weight of wet roots and plant shoots from 16.77 to 137.20 g per plant to 129.23 and 400.40 g per plant, respectively. Meanwhile, root and shoot dry biomass weight grew from 6.40 and 30.46 g per plant to 90.41 and 106.10 g per plant, respectively. The administration of ameliorant, a mixture of rice husk charcoal with compost and cow manure, and mycorrhiza biofertilizer, resulted in the most significant increase in the weight of wet and dry biomass of roots and plant shoots.

Table 3:- At 42 DAP, the average weight of wet and dry biomass of roots and shoots (g/plant) was measured in the ameliorant treatment

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Ameliorant Treatment	Wet biomass		Dry biomass	
	Root	Shoots	Root	Shoots
PO: Control (without ameliorant)	16.77[d]	137.20[e]	6.40[d]	30.46[e]
PA: Rice Husk Charcoal	25.38[c]	219.36[d]	12.83[c]	47.80[d]
PK: Compos	25.55[c]	240.40[c]	14.20[c]	72.06[c]
PS: Cow Manure	72.58[b]	275.58[b]	48.95[b]	85.10[b]
PC: Mixed ameliorant	129.23[a]	400.40[a]	90.41[a]	106.10[a]
HSD 5%	0.79	8.35	3.84	5.00

The application of a mixed ameliorant plus mycorrhiza, up to 20 tons ha$^{-1,}$ enhanced the average weight of wet and dry biomass of roots and plant shoots much more than the control treatment (O_0). The weight of the wet and dry biomass of roots and shoots increased significantly in the combination ameliorant plus mycorrhizal treatment compared to the control. Adding a mixture of organic ameliorants can improve soil's physical, chemical, and biological qualities. This is because mixed organic ameliorants are soil aggregate stabilizers and plant nutrients. Furthermore, mixed organic ameliorants provide energy to most soil microorganisms, including mycorrhizae [25]. This demonstrates that when mixed ameliorants with mycorrhiza are applied to sweet corn plants, there is an increase in plant wet and dry biomass. This rise is caused by an increase in the concentration of N and P in the soil, both essential for plant growth. The ability of mycorrhizae and plants to boost phosphorus nutrient uptake and improve plant growth is the primary benefit of their symbiotic relationship [26]. Mycorrhiza can boost plant nutrition while also increasing plant growth and yield. According to the description mentioned earlier, the administration of mixed organic ameliorants plus mycorrhizae at a dose of 20 t ha-^{1}, In general, can significantly boost plant growth.

D. Number of Spore and mycorrhizal colonization

The results of the diversity analysis revealed that the effect of an ameliorant mixture of rice husk charcoal with compost, cow manure, and mycorrhizal biofertilizers on the parameters of the number of mycorrhizal spores and the percentage of root colonization at 42 DAP was significantly different according to the 5% HSD test compared to the control (Table 4). The treatment of administering an ameliorant mixture of rice husk charcoal with compost, cow dung, and mycorrhizal biofertilizer yielded the highest spore count and colonization percentage, namely 424.33 spores per 100 g of soil and 80.66 percent colonization. The control treatment (no ameliorant) had the fewest spores and colonization percentages, with 71.33 spores per 100 g of soil and 20.30 percent colonization.

Table 4:- At 42 DAP, the average number of spores (spores per 100 g of soil) and colonization (%-colonization) in the ameliorant treatment

Ameliorant Treatment	Number of spores	Colonization
PO: Control (without ameliorant)	71,33[e]	20,30[e]
PA: Rice Husk Charcoal	173,33[d]	40,46[d]
PK: Compos	253,66[c]	50,50[c]
PS: Cow Manure	302,66[b]	60,56[b]
PC: Mixed ameliorant	424,33[a]	80,66[a]
HSD 5%	4,125	0,445

When mycorrhizae were added to organic ameliorants, the available P in the soil tended to increase for each treatment given organic ameliorants. This demonstrates that mycorrhiza can convert soil P from a difficult-to-dissolve form to a soluble one, increasing accessible P. Because they create organic acids and phosphatase enzymes, mycorrhizae are hypothesized to be able to take P from mineral sources that are difficult to dissolve. This molecule can break down insoluble P bonds like Al-P and Fe-P, increasing P availability. The findings of this experiment are consistent with the results of another study, which found that the administration of organic ameliorants and mycorrhizae could increase soil phosphate status in Andisol soils [27]. With a dose of 20 tons ha^{-1}, Ameliorant, a mixture of 80% chicken manure and 20% dolomite, provided the highest dry weight and NPK nutrient absorption in sweet corn plants [28].

IV. CONCLUSION

The application of 20 tons ha^{-1} of mixed ameliorant (25% cow manure + 25% compost + 25% rice husk charcoal + 25% mycorrhiza) increased plant height, number of leaves, available P, and total N concentration in the soil, plant N and P absorption, the number of spores and colonization on roots, and the weight of wet and dry stover plants on sandy soil. Amelioran formulation of 25% cow dung + 25% compost + 25% rice husk charcoal + 25% mycorrhiza gives the highest soil nutrient concentration, plant nutrient uptake, and sweet corn development.

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REFERENCES

[1]. Yazar A, Ali A. 2017. Water harvesting in dry environments. In: Farooq K, Siddique (eds). Innovations in Dryland Agriculture.Springer, Germany
[2]. Agricultural Research and Development Center, 2006. Soil Physical Properties and Analysis Methods. Center for Agricultural Land Resources, Bogor.
[3]. Rachim, D., Arifin, M., 2013. Soil Classification in Indonesia. Pustaka Reka Cipta, Bogor.
[4]. Atmojo, S.W., 2003. The Role of Organic Matter on Soil Fertility and Its Management Efforts. Sebel. Maret Univ. Press 36.
[5]. McGarry, D. 2005. A methodology of a visual soil-field assessment tool. Natural Resources Sciences. Queensland Government, Australia.
[6]. Uzoma, K.C., Inoue, M., Andry, H., Fujimaki, H., Zahoor, A., & Nishihara, E. 2011. Effect of cow manure biochar on maize productivity under sandy soil condition. *Soil use and management*. 27 (2): 205-212.
[7]. Ramos FT, Dores EFDC, Weber OLDS, Beber DC, Campelo Jr JH, & Maia JCDS. 2018. Soil organik matter doubles the cation exchange capacity of tropical soil under no-till farming in Brazil. *Journal of the Science of Food and Agriculture.* 98 (9): 3595-3602.
[8]. Dariah A, Sutono S, Nurida NL, Hartatik W & Pratiwi E. 2015. Soil repairer to increase the productivity of agricultural land. *Jurnal Sumberdaya Lahan*. 9 (2): 67-84.
[9]. Walder F, Niemann H, Natarajan M, Lehmann MF, Boller T, Wiemken A. 2012. Mycorrhizal networks: common goods of plants shared under unequal terms of trade. *Plant Physiol.* 159, 789–797. doi: 10.1104/pp.112. 195727.
[10]. Menge L, Zhang A, Wang F, Han X, Wang D, Li, S. 2015. Arbuscular mycorrhizal fungi and rhizobium facilitate nitrogen uptake and transfer in soybean/maize intercropping system. *Front. Plant Sci.* 6:339. doi: 10.3389/fpls. 2015.00339
[11]. Smith SE, Jakobsen I, Grønlund M, & Smith F A. 2011. Roles of arbuscular mycorrhizas in plant phosphorus nutrition: interactions between pathways of phosphorus uptake in arbuscular mycorrhizal roots have important implications for understanding and manipulating plant phosphorus acquisition. *Plant physiology*. 156 (3): 1050-1057.
[12]. Astiko W, Wangiyana W, Susilowati LE. 2019. Indigenous Mycorrhizal Seed-coating Inoculation on Plant Growth and Yield, and NP-uptake and Availability on Maizesorghum Cropping Sequence in Lombok's Drylands. Pertanika *J. Trop. Agric. Sc*. 42 (3): 1131 – 1146.
[13]. Astiko, W., Isnaini, M., TaufikFauzi, M., & Muthahanas, I. 2022. Application of bioamelioran with local raw materials to the yield of some varieties sweet corn. *International Journal of Innovative Science and Research Technology*. 7(9): 322-329.
[14]. Gomez, Kwanchai A., dan Arturo A. Gomez. 1984. Statistical procedures for agricultural research. John Wiley & Sons. pp. 384.
[15]. Satrahidayat, I. R. 2011. Engineering mycorrhizal biofertilizers to increase agricultural production. UB Press. Malang Indonesia. pp. 226.
[16]. Simarmata, T. 2017. Engineering of Bioameliorant-Based Planting Media to Increase the Productivity of Potted Plants and Yard (Case Study in Tersana Village and Pabedilan Kulon Village, Pabedilan District, Cirebon Regency). *Jurnal Pengabdian Kepada Masyarakat*. 1 (3).
[17]. Astiko W, Fauzi MT, Sukartono. 2016. Nutrient Status and Mycorrhizal Population on Various Food Crops Grown Following Corn Inoculated with Indigenous Mycorrhiza on Sandy Soil of North Lombok, Indonesia." *Journal of Tropical Soils.* 20 (2): 119-125.
[18]. Astiko W, Fauzi MT & Muthahanas I. 2022. Effect of several doses of bioamelioran plus indigenous mycorrhizae on growth and yield of glutinous corn (*Zea mays* var. *ceratina*). *International Journal of Innovative Science and Research Technology*. 7 (10): 168-175.
[19]. Sufardi S, Syakur S & Karnilawati K. 2013. Organic ameliorants and mycorrhizae increased soil phosphate status and maize yields on Andisol soils. *Jurnal Agrista*, 17(1): 1-11.
[20]. Maftu'ah E, Maas A, Syukur A & Purwanto BH. 2013. Effectiveness of ameliorants on degraded peatlands to increase growth and NPK uptake of sweet corn plants (*Zea mays* L. var. *saccharata*). *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)*. 41 (1): 16-23.
[21]. Jala S & Goyal D. 2006. Fly ash as a soil ameliorant for improving crop production—a review. *Bioresource technology*. 97 (9): 1136-1147.
[22]. Tejada M, Garcia C, Gonzalez JL & Hernandez MT. 2006. Use of organic amendment as a strategy for saline soil remediation: influence on the physical, chemical and biological properties of soil. *Soil Biology and Biochemistry*. 38 (6): 1413-1421.
[23]. Astiko W, Isnaini M, Fauzi MT & Muthahanas I. 2023. Growth of Several Varieties of Sweet Corn Added as a Bioameliorant. In *Suboptimal Land National Seminar* (Vol. 10, No. 1, pp. 88-96).
[24]. Bhantana, P., Rana, M. S., Sun, X. C., Moussa, M. G., Saleem, M. H., Syaifudin, M., & Hu, C. X. 2021. Arbuscular mycorrhizal fungi and its major role in plant growth, zinc nutrition, phosphorous regulation and phytoremediation. *Symbiosis*, 84: 19-37.
[25]. Luo S, Wang S, Tian L, Shi S, Xu S, Yang F & Tian C. 2018. Aggregate-related changes in soil microbial communities under different ameliorant applications in saline-sodic soils. *Geoderma*. 329: 108-117.
[26]. Mohammadi K, Khalesro S, Sohrabi Y & Heidari G. 2011. A review: beneficial effects of the mycorrhizal fungi for plant growth. *J. Appl. Environ. Biol. Sci*. 1 (9): 310-319.
[27]. Blackwell, P., Krull, E., Butler, G., Herbert, A., & Solaiman, Z. 2010. Effect of banded biochar on dryland wheat production and fertiliser use in south-western

Australia: an agronomic and economic perspective. *Soil Research*, 48(7): 531-545.

[28]. Lestari, Y., & Maftu'ah, E. 2021. Amelioration and variety selection to increase shallot yield in peatlands. In *IOP Conference Series: Earth and Environmental Science* (Vol. 648, No. 1, p. 012168). IOP Publishing.